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ABSTRACT

The assessment of vision as it relates to and interacts with motor development is reviewed. The focus is on eye readiness skills normally occuring in infants' first few months of life and preceding eye-hand coordination. These visual skills fall into three categories: fixation, tracking, and scanning. Six standardized scales are reviewed and results are reported: Gesell's Developmental Schedules, Bayley Scales of Infant Development, Denver Developmental Screening Test, Cattell Infant Intelligence Tests, Griffiths Mental Development Scale, and Buhler's Test of the First Year of Life. The scales were developed from normative data collected on children ranging in age from birth to six years. Control variables were: sex, race, residence, and education of the head of household. The reliability coefficients included in the scales were split half, test-retest, and tester-observer. Several non-standardized assessment instruments and checklists for use with normal or handicapped children list the developmental sequences and ages at which certain skills emerge: other instruments list visual behaviors along with general descriptions of measurement techniques and definitions of acceptable responses. An overview of research on basic visual capacities of infants is outlined. (Author/GK)

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Review of Measurement Instruments and Procedures for Assessing Visual Behaviors: Implications for Quantitative Measurement

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REVIEW OF MEASUREMENT INSTRUMENTS AND PROCEDURES FOR ASSESSING VISUAL BEHAVIORS: IMPLICATIONS FOR QUANTITATIVE MEASUREMENT

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The purpose of this review is to examine the assessment of vision as it relates to and interacts with motor development. Therefore, the focus is on eye readiness skills that normally occur in the first few months of life and generally precede eventual eye-hand coordination. For the purpose of this review these visual skills fall into three general categories: fixation, tracking, and scanning. Fixation skills involve focusing of the eyes on a specific object or stimulus array. These skills develop sequentially beginning with momentary regard, progressing through prolonged regard and alternating regard until the child is able to reliably fixate on small objects (Gesell, 1928; Griffiths, 1954; and Bayley, 1969). Tracking skills involve movement of the eyes. These skills include the ability to move the eyes horizontally, vertically, and in a circle until the child is able to visually explore the environment (Cattel, 1940; Griffiths, 1954; and Bayley, 1969). Scanning skills involve acquiring information from the visual environment (Day, 1975). As standardized tests, non-standardized assessments, and basic research are reviewed, visual fixation, tracking, and scanning skills will be considered in relation to general measurement techniques, response definitions, testing conditions, and stimulus descriptions.

Standardized Developmental Scales

The standardized scales reviewed included Gesell's Developmental Schedules (Gesell, 1928 and Gesell and Thompson, 1938), Bayley Scales of Infant Development (Bayley, 1969), The Denver Developmental Screening Test (Frankenburg, Dodds, Fandal, Kozuki and Cohrs, 1975), The Cattell Infant Intelligence Tests (Cattell, 1940), The Griffiths Mental Development Scale (Griffiths, 1954), and Buhler's Test of the First Year of Life

(Bühler, 1930). The scales were developed from the normative data collected on children ranging in age from birth to age six. The variables controlled for in most cases were: sex, race, residence, and education of the head of the household. The scales usually included one or more of the following reliability coefficients: split half, test-retest, and tester-observer.

Perhaps the most widely used base for assessing the development of visual skills in infants has been derived from the normative data and theories of Arnold Gesell (Gesell, 1928 and Gesell and Thompson, 1938). Although specific descriptions of physical responses are lacking in these sources, comprehensive descriptions of the testing conditions are provided. Specifically, the child is tested in the supine position and a dangling ring is used to test both fixation and tracking responses. The ring is held about ten inches above the lower end of the child's sternum. To evoke regard of the stimulus, the ring may be moved left or right into the child's line of vision or bobbed up and down slowly. After a fixation response occurs, horizontal tracking is elicited by moving the ring slowly in an arc at the rate of five seconds per 180°. To assess vertical tracking the ring is moved from eye level to six inches above the head and then down to the infant's toes.

In the Bayley Scales of Infant Developmnt (Bayley, 1969), Nancy Bayley provides descriptions of acceptable responses as well as measurement techniques, testing conditions, and stimuli to be used. For testing on the Bayley items relating to eye movements, the infant is placed either in the supine position or sitting position. The tests are given with the mother present and if it is felt that the

mother may be better able to elicit the required behavior, she is asked to present the item. Stimuli used for testing fixation and tracking are a red dangling ring, a human face, a light, a moving person, a pencil, a one-inch cube, and a pellet. Initially the stimulus is placed eight inches from the child's eyes. After movement of the eyes becomes coordinated, the distance is then increased to 12-15 inches. Movement of the stimulus should take approximately three to four seconds for each foot of distance. Horizontal and vertical movements of the stimulus should be made several times to give the child several opportunities to track. For circular tracking, the stimulus should be moved in a circle about 12 inches in diameter. To be considered circular tracking, the child must follow the stimulus in both upper and lower halves, although not necessarily continuously. To assess fixation, the stimulus is presented both in the direct line of vision and outside the line of vision so that the child is required to turn to look. Also, for tracking, the child is tested for the ability to track from midline out, and then from a point in the periphery toward the child's center of vision. For testing scanning, a bell and rattle are shaken alternately. Several seconds between shakes are allowed to give the child the opportunity to move his eyes from one to another.

On the Denver Developmental Screening Test (Frankenburg, Dodds, Fandal, Kozuk, and Cohrs, 1975) visual items are found in the Personal-Social and Fine Motor-Adaptive sections. Brief definitions of acceptable responses and general descriptions of conditions are both included. The child is placed in the supine position for all items up until five months, when the visual activities start to become

coordinated with hand movements. The child is then held sitting on a parent's lap at a table so that the hands can be placed on a table. Stimuli used in testing include a face, a piece of red yarn, and a raisin. For regard of a face, the stimuli should be held within 12 inches of the child. A piece of red yarn is held six inches from the child's eyes for testing tracking and a raisin is placed on a table to test regard. The examiner may shake the yarn or point to the raisin to attract the child's attention. Tracking includes following to the midline position, past midline, and then in a 180° arc. The child may either track with the eyes alone or with the head and eyes together.

The Cattell Infant Intelligence Tests (Cattell, 1940) include descriptions of stimulus items and general procedures in addition to brief criteria for passing an item. A four-inch red ring dangling on a string held about eight inches from the child's eyes is used for tracking while the child is placed in the supine position. The stimulus should be moved at about five seconds per 180° arc and tracking should be continuous throughout the arc. To test regard a one-inch red cube is placed on a table while the child is held sitting in an upright position. A one and a half inch diameter red ball rolled across a table is also used to test tracking.

The Griffiths Mental Development Scale (Griffiths, 1954) makes considerations for the special needs of handicapped as well as of non-handicapped children in the test situation. Descriptions of testing procedures include the stimuli used, conditions, and general measurement techniques. The child may be lying in the supine position or held by the mother in a reclining position. A small colored ball

that rattles is used to attract the attention of the young baby before giving items to test visual skills. Other stimuli used for testing fixation and tracking are a brightly colored ring with attached cord, a ring with attached bells, and a light. Stimuli are held approximately 15-18 inches from the child at right angles to the field of vision. Movement is from center outward and back to center for both vertical and horizontal tracking. Circular tracking should follow a path of about 12 inches in diameter. One item to test scanning is included, in which the infant is required to glance at one object then another. Stimuli used for this item are a ring and a rolling ball. Griffiths notes that too many visual tests should not be taken in succession since it can be very fatiguing to the child.

In The First Year of Life Charlotte Bühler (1930) briefly described testing procedures and acceptable responses for her test. The child is tested in the supine position using a shiny object (she used a wooden disc three and one half inches in diameter covered with tin foil) or the examiner's face positioned at about 12 inches from the child's face as stimuli. To assess tracking, the stimulus is first presented in the child's field of vision, moved to one side then to the other and back to center. On one of the items a light held six inches from the child's face is used to test regard.

Non-Stardardized Assessment

Several non-standardized assessment instruments and checklists for use with normal and/or handicapped children list the developmental sequences and ages at which certain skills emerge. These include: Pennsylvania Training Model Assessment (Somerton and Myers, 1976), Behavioral Characteristics Progression (Santa Cruz, 1973), Infant

Learning Program (Gentry, Note 3), Portage Guide to Early Education (Bluma, Shearer, Frohman, and Hilliard, 1976), Memphis Comprehensive Developmental Scale (Quick, Little, and Campbell, 1974), The Callier-Azusa Scale (Stillman, 1975), Behavioral Development Profile (Donahue, Montgomery, Kaiser, Roecker, and Smith, 1975), and Developmental Pinpoints, (Cohen, Gross, and Haring, 1976). None of these assessments offer clear definitions of responses to be measured, descriptions of measurement techniques, specification of testing conditions or stimuli to be used. The Koontz Child Development Program (Koontz, 1974) and the Learning Accomplishment Profile (Sanford, 1975) provide lists of visual behaviors and the months at which they emerge along with a general description of measurement techniques and definitions of acceptable responses.

Scheuerman, Baumgart, Sipsma, and Brown (Note 4) in Volume VI of Madison's Alternative for Zero Exclusion provided several general considerations for assessment of visual skills of severely handicapped students. In terms of materials, such factors as size, color, pattern, and complexity were mentioned as important. The authors stated that large objects (one to six inches in diameter or width) may facilitate fixation and brightly colored objects may facilitate initial attending. Furthermore, complex patterns and complex structure (e.g., moving parts) may help attract and maintain attending. The authors suggested that persons as well as objects should be used as stimuli. Multi-sense strategies may be employed while initially attempting to verify visual skill development. This includes, for example, using objects that provide auditory as well as visual input. However, this additional sensory input must be

eliminated at some point to accurately assess the child's use of the visual mode to perform the skill. The use of objects or persons for which the student has a demonstrated preference could be used initially, but other objects should also be employed to insure accurate assessment of visual skills.

Scheuerman et al. (Note 4) also provide descriptions of procedures and recommended criterion performance for verification of fixation and pre-tracking skills. In assessing both fixation and tracking, at least two different objects should be presented at eye level in the midline position from within both a short distance (four to eight inches) and a long distance (eight to twelve inches) from the student. Criterion performance for fixation includes alignment of head and at least one eye with the object for a duration of at least one second within five seconds of the presentation. After fixation occurs, tracking should begin within five seconds with both head and the eyes following the object through the desired arc.

Basic Research in Vision

Considerable research has been conducted in the area of vision in infants. Research on basic visual capactities of infants, stimulus-response dimensions, and measurement apparatuses or techniques has important implications for the assessment of visual fixation and tracking.

Research on the basic capacities of infants has shown that the newborn does not easily accommodate (Haynes, White, and Held, 1965), has an average focal distance of 19 centimeters (Haynes et al., 1965), and has some convergence of both eyes on nonmoving objects (Wickelgren,

1967). The shortness of the eyeball in infants results in a tendency toward farsightedness in about 74 percent of newborns (Spears and Hohle, 1967). By four months of age, the infant has the ability to focus at varying distances in a manner equal to normal adults (Spears and Hohle, 1967). Tracking by this time is smooth and efficient (Ling, 1942) and the capacity for binocular vision has improved (Brown, 1961). Ling (1942) studied the development of fixation and found that sustained visual fixation is absent at birth, begins to appear in rudimentary form a few hours later, and peaks at four to five weeks. Eye movements of fixation develop in four stages that include monocular fixation, monocular dominance, alternation of dominance, and finally binocular fixation by about seven weeks.

Numerous studies have been reported that investigated various dimensions of visual stimuli and their effect on responding.

Light. Jones (1926) observed the response of infants to movements of a small flashlight presented at a distance of one foot in a lighted room. The eyes turn slowly toward the light at birth; horizontal, vertical, and rotary pursuit movements were first noted at two weeks, five weeks, and nine weeks respectively. Hershenson (1964) found that the newborn prefers lights of moderate brightness and by three to four months the infant responds to lights of much weaker intensities, indicating a lowering of brightness threshold (Doris and Cooper, 1966).

Color. The photic system is functioning at birth (Barnet, Lodge, and Armington, 1965) and several studies suggest that the newborn can probably discriminate colors (cf. Kessen, Haith, and Salapatek, 1970, for a review). Spears (1964) found that the colors of red and blue are preferred over gray in young infants.

Movement. By two months the infant prefers moving over stationary stimuli (Ames and Silfen, Note 1) and by three months anticipates a regular pattern of movement (Nelson, 1968). Kagan and Lewis (1965) found no difference in preference among six month old infants for a single blinking light, a light moving horizontally, and a light moving in a square helix. However, Cohen (1969) did find a preference for lights blinking in four to sixteen positions over the stationary blinking light. Berkson (1966) has studied eye fixation responses to moving and stationary stimuli in profoundly retarded children. He found that response to the onset of movement was greater than response to offset and the probability of eye fixations on the moving stimulus was maximum immediately after it was presented. Eye fixations declined as a function of the length of time the stimulus was presented.

Response to face. The newborn prefers to look at a regular face over a scrambled face (Fantz, 1961). Infants under the age of three to five weeks fixate facial areas 21% of the time and then concentrate on areas of high contrast, whereas the seven week and older infant fixates on facial areas over 90% of the time (Bergman, Haith, and Mann, Note 2). Fantz (1967) found longer visual fixation to two dots in the eye position of a circle than to two dots in random positions.

Complexity. Fantz (1965) found that the newborn looks more at patterned than nonpatterned stimuli and Hershenson (1964) found a preference for 2 x 2 checkerboards over more complex (12 x 12) checkerboards. However, Friedman, Nagy, and Carpenter (1970) were not able to replicate this finding. Brennan, Ames, and Moore (1966) and Karmel (1969) showed that infants have a preference for more complex checker-

boards with increasing age. However, this result was not found when infants were tested repeatedly over several weeks (Horowitz, Paden, Bhana, Aitchison, and Self, 1972). According to Karmel (1969) the infant between 13 and 20 weeks prefers stimuli with more contour, however, the complexity dimension did not fit these data. Physiological data (Harter and Suitt, 1970) support the fixation results on contour, indicating this is the stimulus variable responsible for the age shift in preference for smaller checkerboard patterns.

Depth and distance. Fantz (1961) has shown that infants between one and four months prefer three-dimensional over two-dimensional stimuli. McKenzie and Day (1972) found that the distance the object is from the child determines the length of fixation; no further than one meter is best.

Novelty. Studies by Friedman (1972) and Saayman, Ames and Moffett (1964) involving newborns and three month old infants, respectively, demonstrated that a novel stimulus is explored visually more than a stimulus which is familiar. _____ ( ) studied habituation of visual fixation in profoundly retarded children age five to sixteen and also found an increase in visual fixation to the novel stimulus by this population.

After a detailed review of the literature, Day (1975) has identified six developmental trends in the area of scanning. With age, there is (1) an increased demonstration of a systematic strategy for acquisition of visual information, (2) increased maintenance of a strategy across variations in context and arrangement of stimuli, (3) more focus on aspects of stimuli most informative for a specific task, (4) increased exhaustiveness and efficiency of visual scanning,

(5) increased speed of visual scanning, and, (6) an enlarged field of view.

Young and Sheena (1975) have summarized and reviewed various measurement techniques used in studying eye movements. Electro-oculography (EOG) measures the position of the eye with skin electrodes placed around the eye. Limbus, pupil, and eyelid tracking involves scanning of the eye with a normal television camera. The most precise measurements of eye movement are made with one of the techniques employing some device tightly attached to the eye with a contact lens. The most common measurement technique is that of corneal reflection, in which the overlap of the reflected stimulus image with the center of the pupil is observed. This method is effective when the stimulus is lighted (Berkson, 1966 and _____), but has also been successful when white stimulus cards are used (Saayman, Ames, and Moffett, 1964).

Illingworth (1970) has described several eye reflexes of the infant in reference to normal and abnormal development. Those which may have some bearing on assessment of fixation and tracking are the "doll's eye" response and the "photic sneeze" reflex. The "doll's eye" response, in which the eyes do not normally move with the head, is always present in the first ten days of the newborn. It disappears therafter, as fixation develops, however, the reflex may persist in abnormal babies. The "photic sneeze" reflex consists of a sneeze when a bright light is shown into the eyes.

Hierarchy of Visual Behaviors

In determining a hierarchy of behaviors (see Figure 1) relating to fixation, tracking, and scanning skills it is necessary to refer

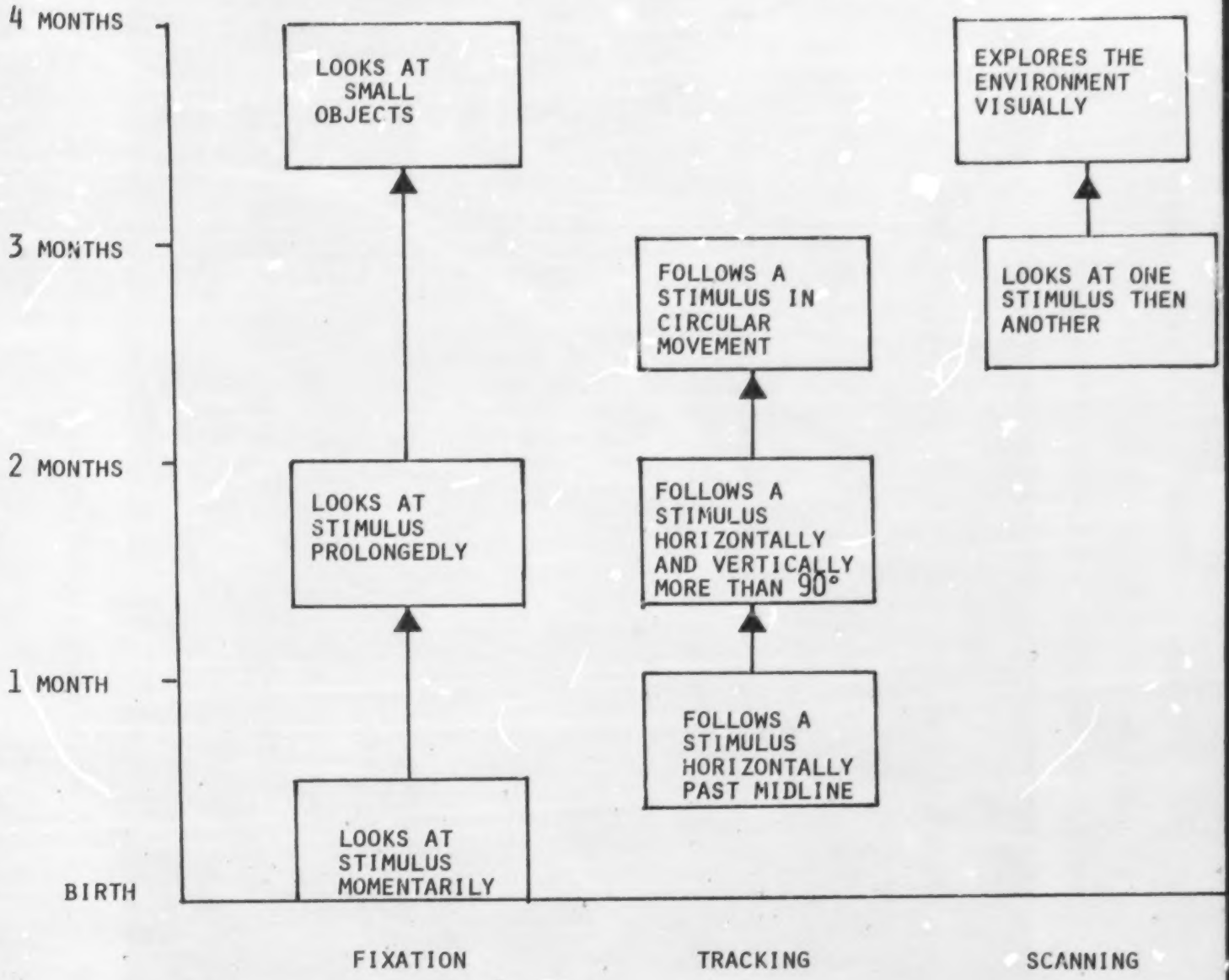

FIGURE 1: LATTICE FOR EMERGENCE OF VISUAL SKILLS

to the normative data and/or developmental scales of Gesell (1928), Gesell and Thompson (1938), Buhler (1930), Cattell (1940), Griffiths (1954), and Bayley, (1969). All of these scales reflect the same general course of development of visual skills, however, they may ascribe different ages at which the individual behaviors become apparent. In the first month, the infant looks at a stimulus momentarily when in the line of vision and is able to follow a stimulus horizontally past midline (Gesell, 1928; Griffiths, 1954; and, Bayley, 1969). These behaviors do not emerge until the second month on Buhler (1930) and Cattell's (1940) developmental scales. However, according to the data from Bayley (1969), the infant should also display prolonged regard, vertical and circular coordination of the eyes in the first month. During the second month the infant exhibits prolonged regard for a stimulus and is able to track both horizontally and vertically more than 90° (Gesell, 1928; Cattell, 1940; and, Griffiths, 1954). By age two months infants in Bayley's sample (1969) were looking at one object then another (scanning) as well as fixating on small objects. By the end of the third month the infant should be tracking circular movements and fixating on one stimulus then another (Cattell, 1940, and Griffiths, 1954). The four month old infant explores the environment visually and is able to fixate on small objects (Gesell, 1928; Buhler, 1930; Cattell, 1940; and, Griffiths, 1954). At about four to five months the child's visual behavior begins to be directed toward manipulation of the environment and eye-hand coordination (Gesell, 1928, and Bayley, 1969).

Discrepencies on specific details other than ages for the emergence of skills occur when the different scales are compared.

These discrepencies are: (1) the position of the child (either supine or held sitting), (2) stimuli used (which may include lights, persons or faces, and a wide variety of objects encompassing several stimulus dimensions), (3) movement involved (either head and eyes moving together or eyes moving alone), (4) number of degrees of the arc tracked in relation to assigned age of acquisition, and, (5) the distance the child is from the stimulus (anywhere from 8 inches to 18 inches).

From the scales reviewed there are three general areas of visual skills to be measured: fixation, tracking, and scanning. Fixation behavior should be measured in terms of frequency and duration of eye contact to the stimulus, types and size of stimuli, location and distance of the stimulus from the child, and position of the child. Tracking behavior measurements should include distance and path tracked (horizontal, vertical, and circular), types and size of stimuli, distance of the stimulus from the child, position of the child, and the speed of movement of the stimulus. Scanning patterns should be measured in terms of frequency, duration, location, and sequence of fixations, types and sizes of stimuli, and position of the child.

The conclusion which can be drawn after reviewing the literature on the development and measurement of visual skills in infants and young children is that the available procedures are far from satisfactory to meet the needs of classroom teachers. The standardized scales and non-standardized assessments are as a whole too vague in terms of measurement techniques, response definitions, testing conditions, and stimulus descriptions. The techniques used in basic

research studies involve expensive and/or technologically intricate equipment which would be beyond the scope of classroom use. What is needed are well defined response definitions of fixation, tracking, and scanning behaviors alorg with relatively inexpensive and uncomplicated apparatuses for reliably measuring those behaviors.

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